Early results with use of gracilis muscle flap coverage of infected groin wounds after vascular surgery

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Introduction: **Management of a nonhealing femoral wound after vascular surgery can pose a challenging problem, particularly when there is prosthetic material involved. We prefer to use pedicled gracilis muscle flaps (PGMFs) to cover problematic groin wounds when more conventional management is not possible.**

Methods: **We describe the technique for using PGMFs to provide groin coverage, report a summary of our short-term and long-term results, and describe why we prefer this reconstructive technique.**

Results: **Twenty PGMFs were placed in 18 patients to treat nonhealing and infected groin wounds. Exposed prosthetic vascular reconstructions were covered with the PGMF in 14 wounds, and in situ autogenous vascular reconstructions were covered in four. Seven wound infections were polymicrobial, 10 had a single gram-positive organism, and one had a single gram-negative organism. *Pseudomonas* cultured out in four wounds, and *Candida* in one wound. Two patients had a virulent combination of methicillin-resistant *Staphylococcus aureus* and vancomycin-resistant enterococcus. Complete healing was initially achieved in all wounds, and no patient died within 30 days of surgery. Two PGMFs failed, at 2 weeks and 2 months, respectively, one from tension on the flap pedicle and one from acute inflow occlusion. Underlying prosthetic reconstruction was salvaged in 12 of 14 wounds; the remaining wounds with autogenous reconstructions or exposed femoral vessels all closed successfully. At a mean follow-up of 40 ± 10 months there were no recurrent groin infections. Seven patients died, at 2.5, 3, 8, 12, 14, 22, and 28 months, respectively.**

Conclusion: **PGMF transposition is an effective option to cover infected or exposed femoral vessels or salvage prosthetic graft material in the groin. In appropriately selected patients, when complete graft removal and extra-anatomic bypass is not an acceptable option, gracilis muscle flap coverage is a viable alternative. The technique is relatively simple, and morbidity from PGMF harvest is minimal.** **(J Vasc Surg 2004;39:1277-83.)**

Management of the septic or nonhealing femoral wound after vascular surgery is a common and challenging problem. This is particularly vexing when prosthetic material is involved. The incidence of prosthetic graft infection ranges from 0.7% to 7% after bypass surgery, and the femoral region is by far the most common site of sepsis.[1,2] Debridement of involved nonviable groin tissue often results in exposure of the bypass graft or native vessels. Similarly, there is the threat of vessel exposure when groin wound healing is slowed after multiple repeat operations or in association with persistent lymphatic leaks.

When prosthetic material becomes exposed, most authors advocate graft removal and extra-anatomic reconstruction. This may not always be a viable alternative, because of either the configuration of the reconstruction or significant comorbidity. Use of a muscle flap to cover exposed native vessels or to salvage prosthetic material used in arterial reconstruction has been advocated in a selected group of patients.[2-5] The goals of mobilizing a muscle flap are to achieve adequate coverage of underlying vessels or prosthetic graft material and to eliminate or control infection in a single procedure that includes definitive closure of the muscle donor site. The tissue that has been mobilized most commonly for coverage of problematic groin wounds is the sartorius muscle flap. Over the last 5 years we have preferred use of the pedicled gracilis muscle flap almost exclusively for coverage of groin wounds after vascular surgery. In this article we describe the technique for using the gracilis muscle to provide groin coverage, as performed by both plastic surgeons and vascular surgeons at our institution; provide a summary of our short-term and long-term results; and describe why we prefer this reconstructive technique.

METHODS

Twenty flap procedures were performed in 18 patients between July 1998 and October 2003 (Table). The flap procedures were performed from 1 week to 7 months after the index revascularization procedure in patients with problems ranging from simple arterial or graft exposure from wound breakdown to grossly septic and abscessed wounds. In two morbidly obese patients bilateral gracilis flap coverage procedures were performed, staged in one patient and concurrent in one patient. All data were analyzed retrospectively from a prospectively maintained reg-

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Procedures and outcomes

Patient	*Age (y)*	*Sex*	*DM*	*BMI*	*Original problem/clinical presentation*	*Prosthetic/ other material*	*OR culture results*
1	58	F	Y	35	Infected common femoral patch angioplasty/exposed graft secondary to wound breakdown	ePTFE	*Pseudomonas aeruginosa, Enterococcus faecalis, Staphylococcus epidermidis*
2	60	F	Y	46	Infected femoropopliteal bypass	ePTFE	No organisms
3	80	M	Y	23	Exposed aortobifemoral bypass Femorpopliteal bypass	Dacron, ePTFE	*Staphylococcus aureus*
4	82	M	Y	28	Removal of infected femoral AV graft/septic groin	ePTFE	*E faecalis*
5	41	F	N	29	Wound breakdown after groin dissection because of tumor	None	*P mirabilis*
6	75	F	Y	28	Infected femorpopliteal bypass/septic groin	ePTFE	*P aeruginosa, Candida albicans*
7	57	F	Y	19	Exposed femoropopliteal bypass/exposed graft secondary to wound breakdown	ePTFE	*E faecalis*
8	50	F	Y	40	Prosthetic graft removal, common or deep femoral endarterectomy/septic groin	None	*E faecalis, P aeruginosa*
8	51	F	Y	40	Infected femorotibial bypass/septic groin	ePTFE	*Klebsiella pneumoniae, P aeruginosa*
9	51	F	N	25	Mycotic common femoral pseudoaneurysm	None	*S aureus*
10	67	M	Y	33	Femorofemoral bypass/exposed graft secondary to wound breakdown	ePTFE	*Peptostreptococcus*
11	70	F	Y	44	Femorofemoral bypass Femorotibial bypass/exposed graft secondary to wound breakdown	ePTFE, RSV	No organisms
12	54	M	N	37	Perclose of catheterization site/septic groin	None	*S aureus*
13	70	M	N	38	Femoropopliteal bypass/septic groin	ePTFE	MRSA, VRE
14	57	M	Y	21	Thoracobifemoral bypass Femoropopliteal bypass/exposed graft secondary to wound breakdown	ePTFE	*Escherichia coli, Bacillis fragilis*
15	77	F	Y	37	Reconstruct infected vein patch blowout	Vein patch blowout	MRSA, VRE *Peptostreptococcus, K pneumonia*
16	68	M	N	24	Iatrogenic AVF from catheter/septic groin	None	*S epidermidis*
17	73	M	N	28	Femorofemoral bypass/exposed graft secondary to wound breakdown	ePTFE	*S aureus*
18	59	F	Y	38	Axillofemoral and femorofemoral bypass/exposed graft secondary to wound breakdown	ePTFE	*S epidermidis*
18	59	F	Y	38	Femorofemoral bypass/septic groin	ePTFE	*S epidermidis*

DM, Diabetes mellitus; *BMI,* body mass index; *RSV,* reversed saphenous vein; *AVF,* arteriovenous fistula; *ePTFE,* expanded polytetrafluoroethylene; *MRSA,* methicillin-resistant *Staphylococcus aureus; VRE,* vancomycin-resistant *Enterococcus.*

istry of patients, according to guidelines mandated by the institutional review board of Northwestern University Feinberg School of Medicine. Data collected included patient comorbid conditions, patient weight and body mass index (BMI), original vascular procedure, exposed vascular structures, microbiology results, and flap or donor site complications. BMI was estimated with the formula, Weight(kg)/[height(m)]^2. Short-term and long-term outcomes were assessed, including wound closure, graft salvage, limb salvage, and 30-day and late mortality.

Technique. We use an extended approach for harvest of the gracilis muscle flap. This enables additional vascular pedicle length to facilitate passage to the involved groin.[6] The gracilis muscle is approached through an overlying 8-cm to 10-cm longitudinal medial thigh incision. This incision is usually placed at an orientation slightly posterior to the incision used for greater saphenous vein harvest. If the saphenous vein has recently been procured, the same harvest incision can be used to mobilize the gracilis muscle. The adductor longus muscle is identified and reflected medially. Three aids to identification of the gracilis muscle are as follows: (1) no superficial sensory or motor nerves are encountered during the dissection; (2) the dissecting finger can slide up and down the muscle on the deep and superficial surfaces without difficulty; and (3) the muscle begins to taper and becomes tendinous two thirds of the way down the thigh, whereas the sartorius muscle retains its rectangu-

(Continued)

Antibiotic	*Disposition at time of flap*	*Flap complications*	*Donor site complication*	*Prosthetic salvage*	*Late death*
Ampicillin/sulbactam, vancomycin	Prosthetic patch left in-situ	none	none	yes	no
Vancomycin, amikacin	Prosthetic graft left in situ	yes–flap necrosis	none	no	2.5 mo
Vancomycin, levofloxacin	Prosthetic graft left in situ	none	none	yes	12 mo
Vancomycin, gentamicin	Graft stump oversewn and covered	none	none	yes	22 mo
Ampicillin/sulbactam	Exposed vessels covered	none	none	N/A	28 mo
Vancomycin, amikacin, piperacillin-tazobactam, fluconazole	Prosthetic graft left in situ	none	yes	yes	8 mo
Amikacin, linezolid, oxacillin	Prosthetic graft left in situ	none	yes	no	no
Meropenem, piperacillin-tazobactam	Vein patch placed and covered	yes–partial necrosis	none	N/A	no
Meropenem, piperacillin-tazobactam	Prosthetic graft left in situ	none	none	yes	no
Vancomycin	Cadaveric homograft ileofemoral bypass placed	none	none	N/A	no
Piperacillin-tazobactam	Prosthetic graft left in situ	none	yes	yes	no
Piperacillin-tazobactam	Prosthetic and autogenous grafts left in situ	none	none	yes	no
Vancomycin	Vein patch arterial repair	none	none	N/A	no
Vancomycin, rifampin, amikacin	Prosthetic graft left in situ	yes–subflap hematoma	none	yes	14 mo
Vancomycin, ceftazidime	Prosthetic grafts left in situ	none	none	yes	3 mo
Vancomycin, tobramycin, levofloxacin, fluconazole	Cadaveric homograft ileofemoral bypass	none	none	N/A	no
Vancomycin	AVF repaired primarily	none	none	N/A	no
Vancomycin	Prosthetic graft left in situ	none	none	yes	no
Levofloxacin	Prosthetic graft left in situ	none	none	yes	no
Levofloxacin	Prosthetic graft left in situ	none	none	yes	no

lar and muscular appearance. After incising its overlying investing fascia, the medial and lateral aspects of the gracilis muscle edges are thoroughly exposed. Care is taken to expose the dominant vascular pedicle on the deep medial surface of the gracilis muscle as it courses beneath the adductor longus muscle. It is important to dissect the adductor longus muscle on both sides of the gracilis muscle vascular pedicle from its connections to the sartorius muscle and the adductor magnus muscle. The gracilis muscle is then detached distally from its insertion site on the medial femur via electrocautery, to enable distal mobilization (Fig 1). All minor segmental pedicles should be identified and ligated. During elevation of the muscle from its native bed it is important to ensure preservation of the major vascular pedicle from the medial femoral circumflex artery (from the profunda femoral artery, 10 cm distal from the pubic symphysis).[7] The most critical part of the dissection is careful use of metal clips to ligate and divide the small vessels from the pedicle that course into the overlying adductor longus muscle. Once the proximal extent of the gracilis muscle dissection is reached, we then use electrocautery to detach the gracilis muscle from its origin at the pubic symphysis. At this point, fixation should exist only with the major vascular pedicle[7] (Fig 2). The gracilis muscle is then passed beneath the adductor muscle,[3] through the interspace between the adductor and the sartorius muscles, and into the femoral triangle (Fig 3). The existing groin wound is debrided as necessary, and the muscle flap is positioned to cover the exposed vessels.[8] Monofilament sutures may be used to secure the flap in the desired position. Closed suction drains are placed both in the harvest region and optionally beneath the transposed muscle flap.

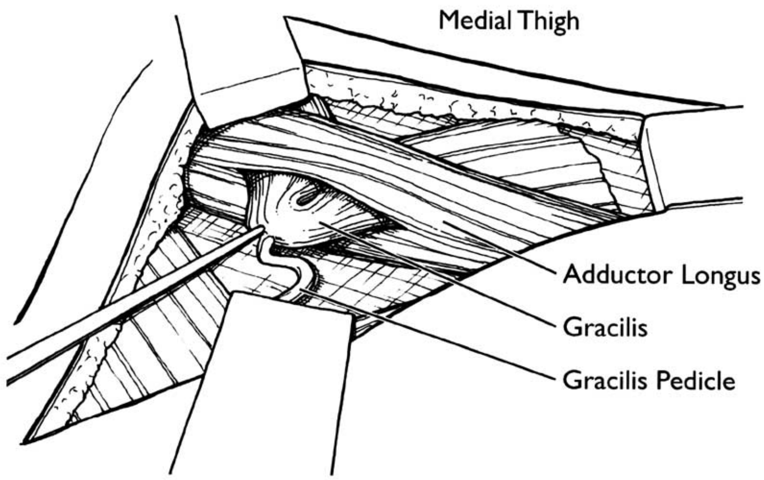

Fig 1. Schematic of gracilis muscle harvest.

RESULTS

The average age of the patients with wounds treated with gracilis muscle flap coverage was 64 ± 4 years. Ten patients were women, eight were men. Twelve patients (67%) had diabetes, and average BMI was 32 ± 2 kg/m^2.

Most infections were diagnosed clinically on the basis of wound appearance, but all patients also underwent computed tomography to determine the extent of the problem. An underlying patent vascular reconstruction had been performed with expanded polytetrafluoroethylene (ePTFE) or Dacron, and subsequently became exposed in 14 of 20 groins (70%). All of these were left in situ and covered with a flap. The single unilevel ePTFE prosthetic reconstructions consisted of five femoropopliteal bypass procedures, one femorotibial artery bypass, three femorofemoral artery bypass procedures, one femoral patch angioplasty, and the prosthetic stumps of an oversewn artery-vein dialysis graft. In a single patient one limb of a thoracobifemoral bypass and a sequential femoropopliteal bypass was covered with gracilis muscle. In another patient the exposed groin contained both a Dacron aortofemoral limb and ePTFE femoropopliteal bypass. In one groin, both the distal anastomosis of an axillofemoral bypass and the proximal anastomosis of a femorofemoral artery bypass became exposed.

The other six flaps (30%) were created to cover exposed native vessels or a simultaneously placed autogenous or cadaveric tissue arterial reconstruction. In one patient the native common, deep, and superficial femoral arteries became exposed secondary to an infected lymphocele that developed after a groin node dissection in a patient with vulvar cancer. In two patients a gracilis muscle was mobilized to cover an in situ cadaveric homograft used to replace a mycotic common femoral artery aneurysm in an intravenous drug abuser, and a blown-out infected vein patch in another patient. In a fourth patient a femoral artery that had become grossly infected, and with a mycotic pseudoaneurysm that developed as a result of an infected Perclose device, was reconstructed with a saphenous vein patch and covered with a flap. In a fifth patient, an infected and occluded prosthetic femorotibial artery bypass graft was removed, and the common and deep femoral arteries were endarterectomized and patched with vein before flap creation. A final case involved an exposed common femoral artery in an infected groin wound that developed after primary repair of a puncture-related iatrogenic arteriovenous fistula.

The sole cultured infectious agent was a gram-positive bacterium in 10 of 20 groins (50%) and a single gram-negative bacterium in one groin (5%). Seven groin wounds (35%) had polymicrobial infections; six of these included at least one gram-negative organism. Two groins (10%) had no organisms grown from the intraoperative culture. Four of the 14 groin wounds cultured positive for *Pseudomonas* species, another grew *Candida*. Two patients had a virulent combination of methicillin-resistant *Staphylococcus aureus* and vancomycin-resistant enterococcus.

No patients died within 30 days of the gracilis flap procedure, and no patient bled from the vessels in the infected groin. Partial or full flap necrosis developed in two patients, and a prosthetic graft could not be salvaged in a third patient. One flap became necrotic after 2 months, when the endarterectomized and patched deep femoral artery and an underlying prosthetic bypass graft became occluded. This patient refused hip disarticulation, and died 2 weeks later. The second patient had untoward tension on the gracilis pedicle, which caused partial flap necrosis. The defect ultimately healed, and the vein patch beneath was salvaged with wound debridement and dressings. In one patient a prosthetic graft was lost despite a viable flap, due to suture line involvement with persistent infection. After the infected graft was removed the native femoral vessels were patched with vein and re-covered with the viable gracilis muscle flap. This patient required ipsilateral limb

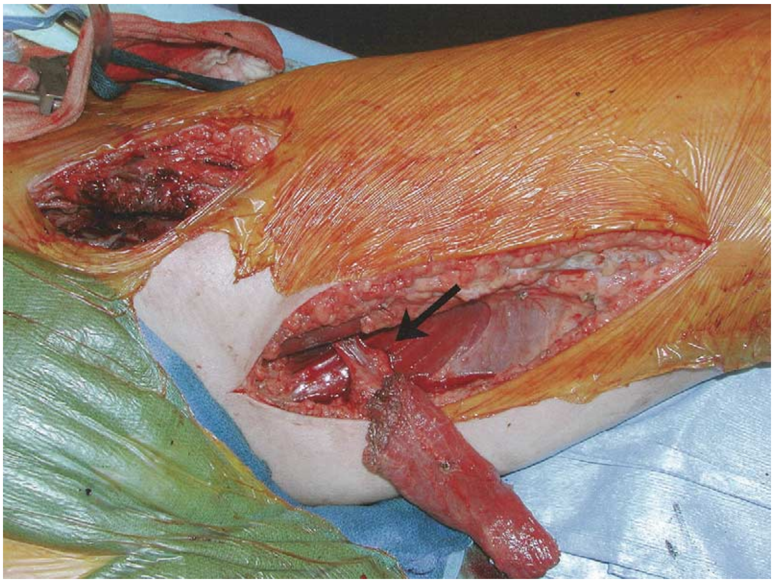

Fig 2. Harvested gracilis muscle on single profunda-based pedicle *(arrow)*.

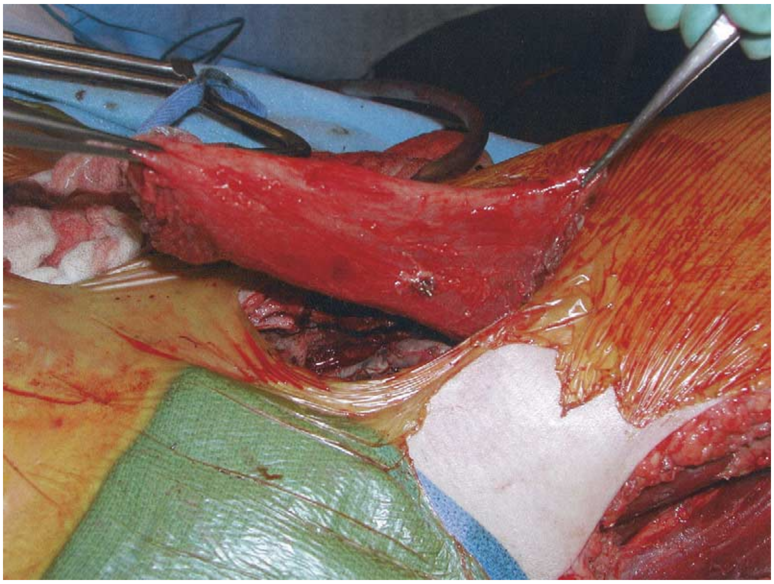

Fig 3. Gracilis flap mobilized and tunneled up to groin wound.

amputation above the knee. In three patients minor donor site skin-edge necrosis developed, and a fourth patient required return to the operating room to evacuate a sub-flap hematoma; all were treated successfully with local wound care. Successful wound healing was ultimately achieved in 19 of 20 groins (95%), and complete and long-term prosthetic graft salvage was achieved in 11 of 13 patients(85%).

Eleven of 18 patients (61%) remain alive. One patient refused hip disarticulation, and died 2.5 months after placement of a gracilis flap, described in detail above. One patient died of a myocardial infartion in a subacute care facility 3 months after coverage of a thoracofemoral and femoropopliteal bypass. One patient died 12 months after the flap procedure, of rupture of an ipsilateral infected ePTFE anastomotic pseudoaneurysm, presumably due to unresolved infection despite a viable muscle flap. The other four patients died at 8, 14, 22, and 28 months, of stroke, congestive heart failure, complications of renal failure, and metastatic cancer, respectively. At mean follow-up of 40 ± 10 months there have been no other recurrent groin infections, and no other survivors have lost a limb.

DISCUSSION

Muscle flap coverage to treat incisional breakdown or groin sepsis has been advocated in selected groups of patients by a number of authors.[1,3-5,8,9] A pedicled muscle flap can improve the local wound-healing environment and can assist in salvaging exposed prosthetic material in some cases. The transposed muscle provides a well-vascularized organ capable of transporting oxygenated blood into the covered region. The vascularized muscle increases local oxygen tension in the area and enhances the ability of macrophages to combat infection. Increased blood flow also provides a medium for the transport of antibiotic agents into the area of infection. Furthermore, the overlying muscle provides an ideal base for a skin graft, if required once deeper healing has occurred.[1]

When graft removal and extra-anatomic bypass is a viable option or if in situ reconstruction with autogenous or cadaveric homograft tissue can be performed, we prefer these more definitive operations. Otherwise, gracilis muscle flap coverage has become our preferred, if not exclusive, method for managing incisional breakdown and sepsis after vascular surgery when more definitive therapy is not an option. Although the flap harvest technique can be a bit more challenging than that used to create a sartorius muscle flap, there are a number of advantages to the use of gracilis muscle compared with the more conventional rotational muscle flaps. First, many patients with vascular disease have an occluded superficial femoral artery, the vessel that supplies the sartorius muscle. Thus perfusion to the segmentally supplied sartorius muscle is often compromised in these patients. This segmental pattern is also an important consideration, because three or more pedicles typically must be ligated to enable adequate mobilization of a sartorius flap for use in the infected groin region. Conversely, the blood supply to the gracilis muscle, despite previous reports,[10] is derived from a single branch of the profunda femoral artery, which is more likely to be spared from atherosclerosis than is the superficial femoral artery. There is also value to obtaining a muscle from a site that is remote from active infection, distant from the bypass conduit, and in an area that is simple to close primarily after harvest.[1] Furthermore, morbidity and functional deficits are clearly fewer with use of a gracilis muscle flap compared with use of a rectus femoral or a rectus abdominal flap, which are two other choices described for reconstruction of the septic groin.

To date, use of the gracilis muscle for groin wound coverage has not been widely accepted, largely because of perceived difficulties involved with flap harvest and muscle size. This misconception regarding flap harvest likely stems from the muscle's relatively remote location medial to the adductors and because of relative unfamiliarity with the dissection. Indeed, isolation of the gracilis muscle by traditional methods may not provide adequate pedicle length to safely reach the groin. We circumvent this difficulty by using an extended harvest technique similar to methods previously described for other pedicled muscle flaps.[11] The advantage of extended harvest is that there is no tension on the vascular pedicle after the muscle is passed beneath the adductor muscle and positioned in the groin. In most cases, with extended harvest the flap will reach as high as the lower quadrant of the abdomen onto the external iliac artery. We have used the gracilis muscle to treat infections that extend proximally and deep to the inguinal ligament. This is compared with the sartorius muscle, which barely has adequate length and width to cover the common femoral artery as it emerges from beneath the inguinal ligament. With extended harvest techniques the widest aspect of the gracilis muscle rests directly in the femoral triangle. Thus this muscle can fill a fairly large defect. Liberal dissection of both sides of the adductor provides full circumferential view of the gracilis muscle vascular pedicle. If this important step is not completed, pedicle tension and flap ischemia can occur. In our series, one instance of partial flap necrosis resulted from tension on the pedicled flap. This did not prevent healing, and the underlying vein patch was successfully salvaged. Once the method for gracilis muscle flap harvest has been mastered, it is no more complex than most other harvest techniques.

The appropriate patient to consider for salvage of an arterial reconstruction with a muscle flap has a patent vascular reconstruction with an intact anastomotic suture line and an open profunda femoris artery. Bleeding from the infected groin site strongly suggests anastomotic involvement and is a relative contraindication to attempted graft salvage. In addition, patients with extensive infection involving the entire length of an aortoiliac or infrainguinal prosthetic bypass shall not be considered candidates for local groin wound coverage. Initial treatment involves systemic antibiotic administration, wound culture, and operative groin debridement. Aggressive and wide soft tissue debridement is necessary in the grossly infected groin wound to significantly reduce bacterial counts and the burden of infection. Muscle transposition may be performed immediately after groin wound debridement if sepsis is readily controlled, or may be delayed, generally for a day or two, provided there is not an extensive length and depth of graft exposed. We have used both traditional saline solution dressings and hydrating topical gels during this period while sepsis is clearing. We have also used closed suction dressings to first promote granulation tissue after the wound has been cleaned and debrided but before the flap is carried out.

It is important to assess patency of the donor flap vessels before committing the patient to this type of intervention. We suggest re-review of the magnetic resonance image or contrast-enhanced angiogram before proceeding, and early intraoperative assessment of the patency of the vascular pedicle with a handheld Doppler scanning probe. In no patient thus far has gracilis muscle harvest been aborted because of inadequate blood flow to the flap, although one flap did die when a reconstructed deep femoral artery became occluded.

Some authors suggest that if a prosthetic graft is infected with gram-negative organisms, especially *Pseudomo-*

nas species, or a fungus, complete removal of the graft is mandatory.[12-15] In our experience, seven of 20 groin infections (35%) treated with gracilis transposition had wound infections involving gram-negative organisms. All four prosthetic grafts that cultured positive for at least one gram-negative organism were successfully salvaged. In addition, four patients with successful wound closure cultured positive for *Pseudomonas aeruginosa* or *Candida albicans*, and another two wounds had both methicillin-resistant Staphylococcus aureus and vancomycin-resistant enterococcus, all of which would be considered particularly virulent organisms. We recommend treatment with intravenous antibiotic agents, on the basis of intraoperative culture results, for 6 weeks in patients with autogenous reconstructions and as long as 1 year in patients with patent prosthetic grafts. It is important to note that these prosthetic graft infections are likely not truly eradicated, and many patients may continue to harbor bacteria in small numbers over the long term. While a vascularized muscle flap may control the infection and provide durable clinical success, late infectious complications can still arise, and lifelong suppressive doses of an antibiotic agent should be considered in selected cases.

CONCLUSION

Gracilis transposition is an effective option to cover exposed vessels or salvage prosthetic graft material. In appropriately selected patients with vascular reconstructions and groin infection, when complete graft removal and extra-anatomic bypass is not an acceptable option, gracilis muscle flap coverage is a viable alternative. The technique is relatively simple, and, in general, any resulting morbidity from gracilis muscle harvest is minimal.

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